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MATERIALS DETERIORATION IN TROPIC VERSUS CONUS SITES,(U)
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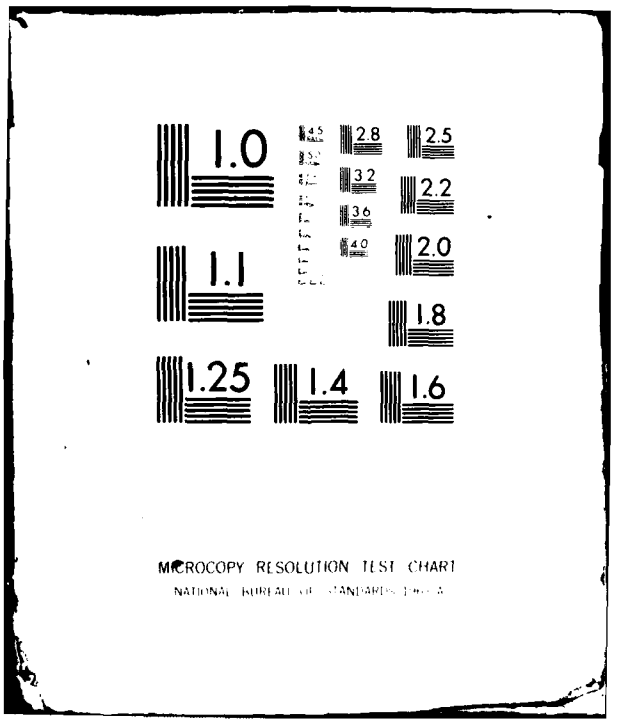
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MATERIALS DETERIORATION IN TROPIC VERSUS CONUS SITES

JUN 1980

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The US Army has had considerable involvement in the humid tropics since before World War II. These involvements have revealed many unexpected materiel problems. Warm temperatures, high rainfall and high humidity interact to produce an environment which adversely affects the performance of materiel. The US Army Tropic Test Center (USATTC), located in the Republic of Panama (latitude 9°N, longitude 80°W), conducts materiel tests and environmental research to increase the effectiveness of systems designed to operate in humid tropic areas.

The continued availability of test facilities in Panama is questionable after the year 2000 because of changing international political situations. In addition, increasingly sophisticated equipment, increases in materiel system inventory, and bulk of Army equipment make it difficult to test in areas remote from the Continental United States (CONUS). Recognizing these real and potential problems, the Army Scientific Advisory Panel (now the Army Science Board) recommended in 1976 that a program of correlative tests be initiated between Panama sites and selected CONUS sites. The concept of using CONUS sites to predict materiel performance in the tropics may be a necessity in the near future.

To determine if this concept is feasible, this research takes an exploratory first look at material performance at a basic level. A number of single environmental factors such as temperature, relative humidity, and rainfall are being measured for their effects on several basic materials such as latex and steel. The approach compares basic degradation curves from material samples exposed at

CONUS sites to deterioration rates and mechanisms found in the tropics of Panama. At the end of this study, correlations between single and multiple environmental factors and degradation rates will be made. This research then takes a basic look at material degradation. There is no attempt at this exploratory stage to predict materiel system performance in the tropics by analyzing data obtained in CONUS, although this project is the first step in that direction. Subsequent research will help to achieve that ultimate goal.

At present, USATTC is studying six areas in CONUS that have some environmental characteristics similar to those found in Panama. Exposure sites have been established at locations in CONUS shown in figure 1. Figure 2 shows the location of the Panama exposure sites; figure 3 identifies analog parameters for CONUS and tropic sites.

Several basic materials and several standard Army materiel items are being exposed as shown in figure 4. These basic materials were exposed during previous tests.(1-6) The knowledge obtained from these tests will be used to compare the severity of the environment to the deterioration of materials and materiel exposed in this study. The same exposure design and analytical procedures will be used for all sites. Since data for all sites have not been collected, the results at this time are not complete. However, some preliminary degradation trends from early exposure data show that the basic concept of using CONUS data to predict tropic results may be feasible. One preliminary result from the study is the percent corrosion weight loss at different sites over a period of time (figure 5). The two coastal sites, Key West and Fort Sherman Coastal, exhibited the highest rate of corrosion. Common deteriorating factors were high atmospheric salt levels, high humidity, and high temperatures. As expected, the Quinault site, with low atmospheric salt, high humidity, and low temperatures had the lowest rate of deterioration. As shown in figure 5, high humidity alone does not accelerate corrosion.

Another early result at this stage of the study is the change in tensile strength for latex and POL tank fabrics (figures 6 and 7). Because latex is sensitive to ultraviolet (UV) radiation, the tensile strength for latex drops rapidly at all sites that have intense solar radiation, but not as rapidly in forest sites. Because the nylon fibers in the POL tank fabrics are not exposed but are contained between layers of PVC and nitrile-neoprene, the tensile strength of POL tank fabrics did not change during any exposure testing. UV radiation cannot penetrate the PVC layers to deteriorate the nylon.

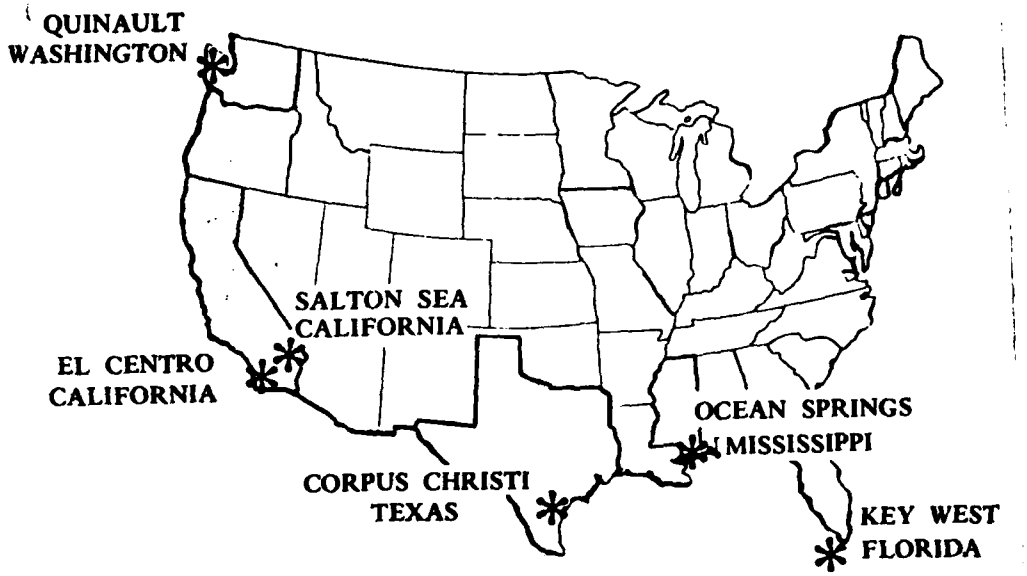

Figure 1. Location of CONUS Exposure Sites.

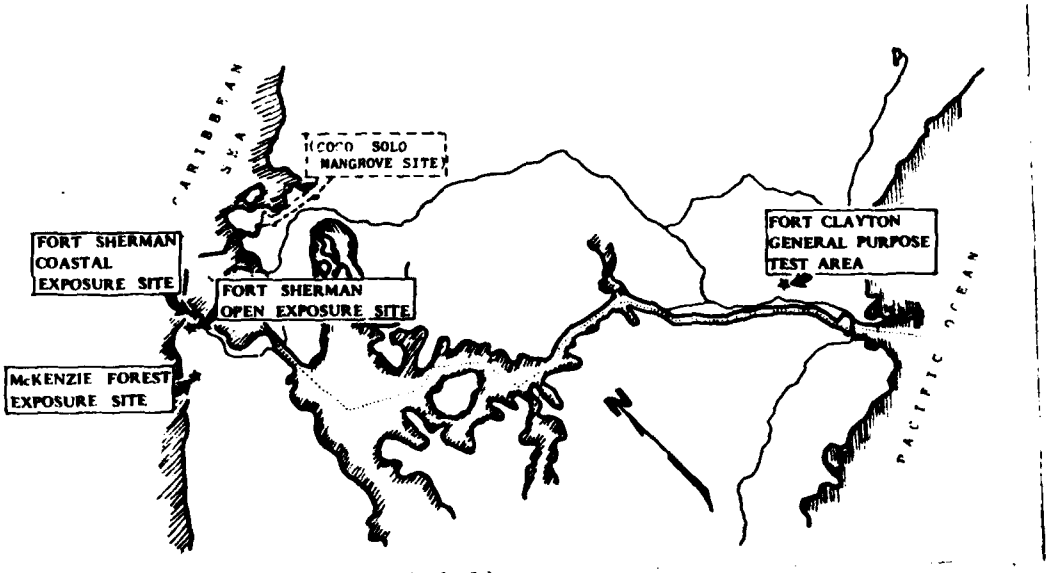

Figure 2. Location of Panama Exposure Sites.

CONUS SITES	ANALOG ENVIRONMENTAL PARAMETERS	PANAMA SITE
QUINAULT, WA	HIGH RAINFALL, HUMIDITY AND ACTIVITY	BATTERY McKENZIE FOREST SITE
SALTON SEA, CA	HIGH AMBIENT TEMPERATURE, SOLAR RADIATION AND HUMIDITY	FORT SHERMAN OPEN EXPOSURE SITE AND FORT CLAYTON GENERAL PURPOSE TEST AREA
EL CENTRO, CA	HIGH SOLAR RADIATION AND AMBIENT TEMPERATURE	FORT SHERMAN OPEN EXPOSURE SITE
CORPUS CHRISTI, TX	HIGH ATMOSPHERIC SALT, HIGH SOLAR RADIATION	FORT SHERMAN COASTAL EXPOSURE SITE
OCEAN SPRINGS, MS	SUBTROPICAL MARINE CLIMATE, HIGH SUMMER HEAT, HUMIDITY AND RAINFALL	PREVIOUS MANGROVE SITE RESULTS
KEY WEST, FL	TROPICAL MARINE CLIMATE DURING CERTAIN MONTHS	FORT SHERMAN COASTAL EXPOSURE SITE

Figure 3. Analogy Between CONUS and Panama Exposure Sites.

TEST ITEMS

Low Carbon Steel	Jungle Fatigues (Strips)
Cotton	Petroleum, Oil, Lubricant (POL) Tank Fabrics
Latex	Electronic Components
Nylon	Jungle Boots
Mylar	Assorted Glues
Cellulose Acetate	

Figure 4. List of Test Items.

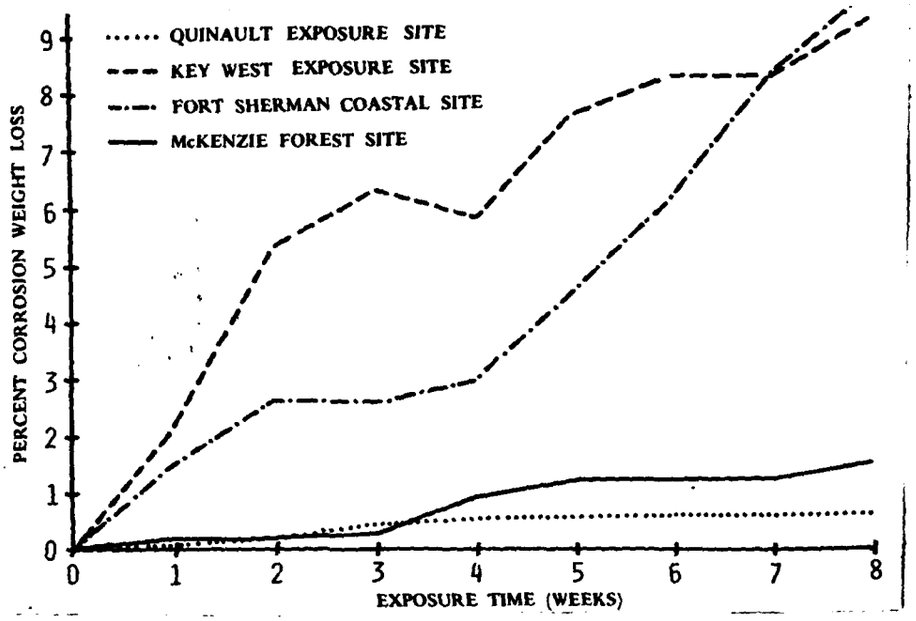

Figure 5. Percent Corrosion Weight Loss at Selected Exposure Sites.

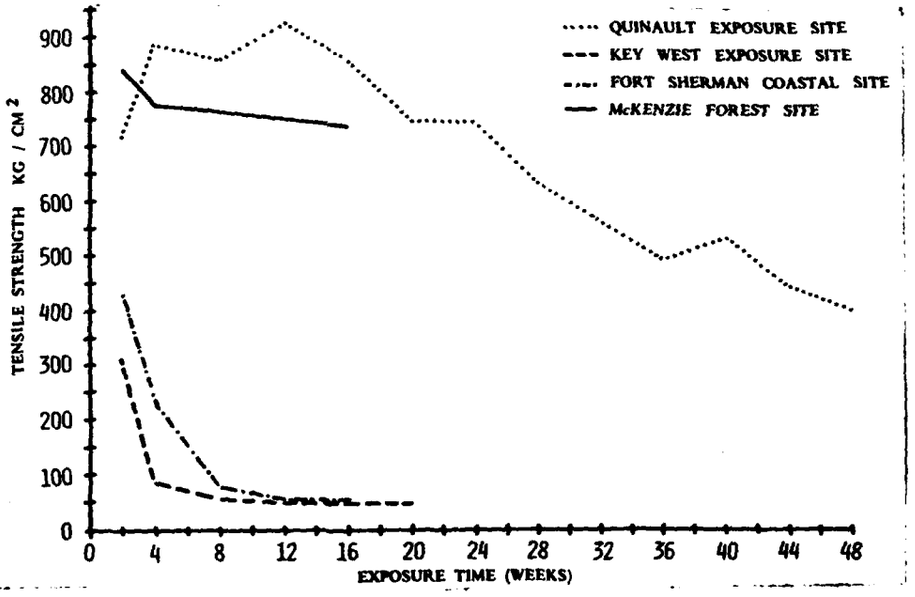

Figure 6. Change in Tensile Strength for Latex at Selected Exposure Sites.

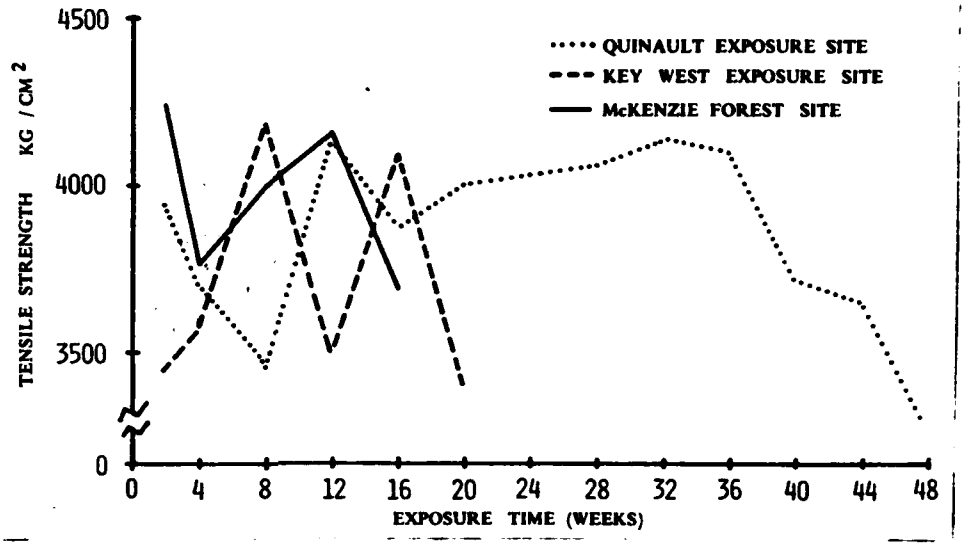

Figure 7. Change in Tensile Strength for POL Tank Fabrics at Selected Exposure Sites.

Environmental degradation occurs most readily on the surface of the POL tank fabric. Therefore, a scanning electron microscope was used to determine the various results in surface deterioration. Figure 8 shows severe deterioration of POL tank fabric exposed for 2 weeks at Key West, a coastal site. Some sections of this fabric had deep cracks. The same result of cracking occured, but not severely, on fabrics exposed at McKenzie Forest in Panama (figure 9). The McKenzie Forest sample also contained fungal activity with a collection of debris and salts. The deterioration process was different for fabrics exposed at Quinault; the fabric did not crack but curled. Figure 10 shows a POL tank fabric that had been exposed at Quinault for 7 months.

One main difference between exposure at Key West and its counterpart in Panama--Fort Sherman Coastal--was fungal activity. Cellulose acetate samples exposed for 2 weeks in Key West did not show evidence of fungal attack, but did exhibit surface deterioration (figure 11). However, samples exposed for 2 weeks at the Fort Sherman Coastal site were covered with fungal mycelia, debris and salts (figure 12).

Jungle fatigue strips also were used as exposure samples (figures 13 and 14), undergoing exposure for 2 weeks at the Fort Sherman Coastal Site. The fatigue strips contained a fungus

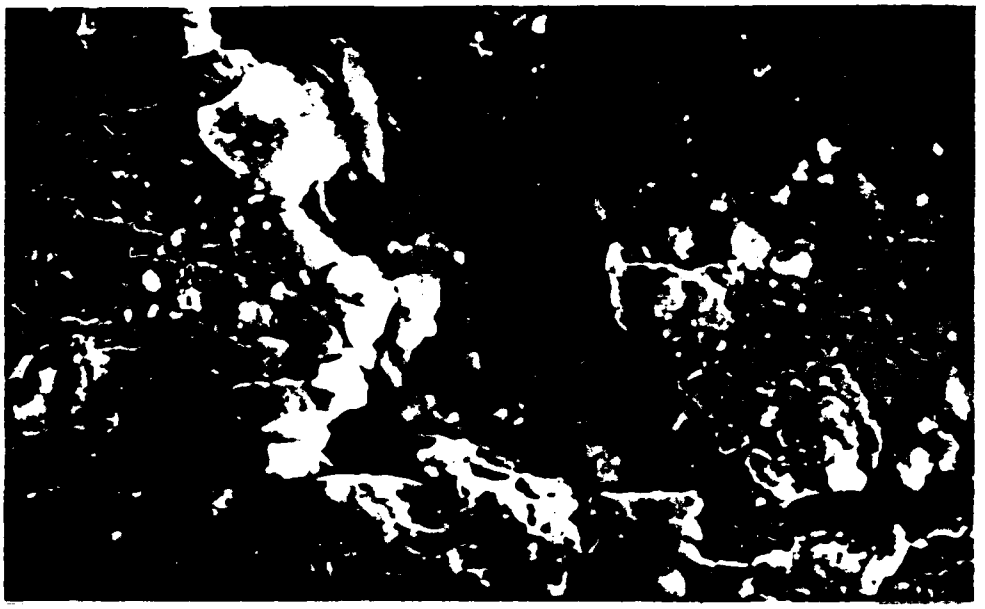

Figure 8. Photomicrograph of Deterioration to Surface of POL Tank Fabric Exposed at Key West for 2 Weeks, 560X.

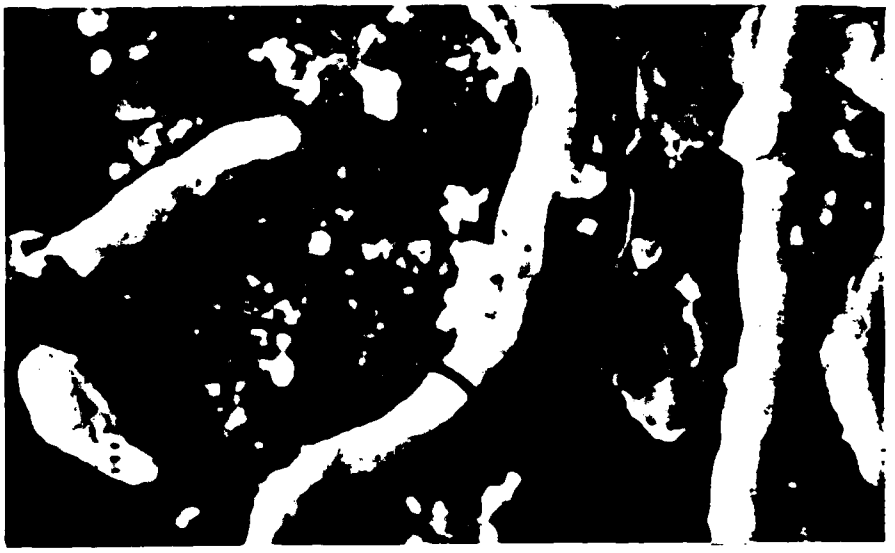

Figure 9. Photomicrograph of Deterioration to Surface of POL Tank Fabric Exposed at McKenzie Forest for 2 Weeks, 1200X.

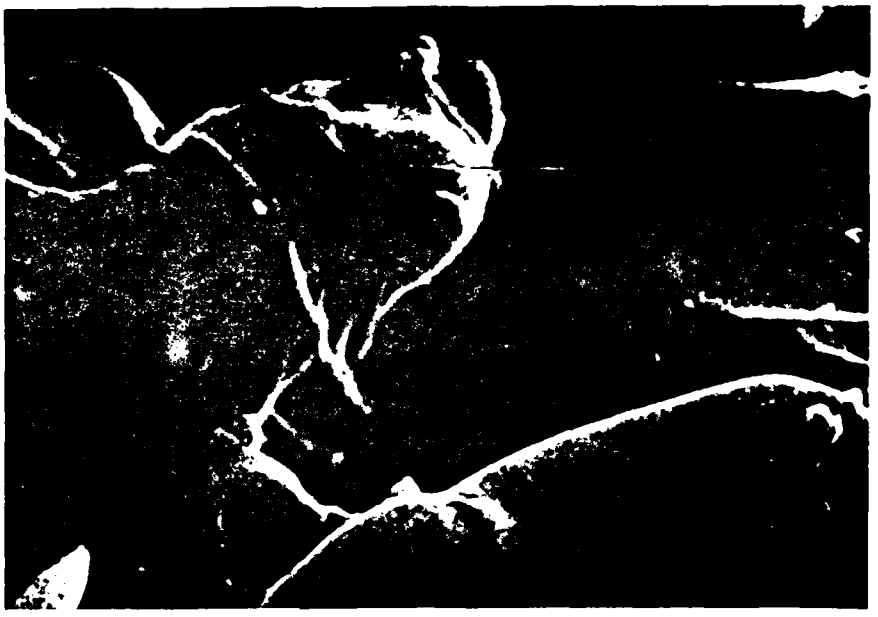

Figure 10. Photomicrograph of Deterioration to Surface of POL Tank Fabric Exposed at Quinault for 7 Months, 1000X.

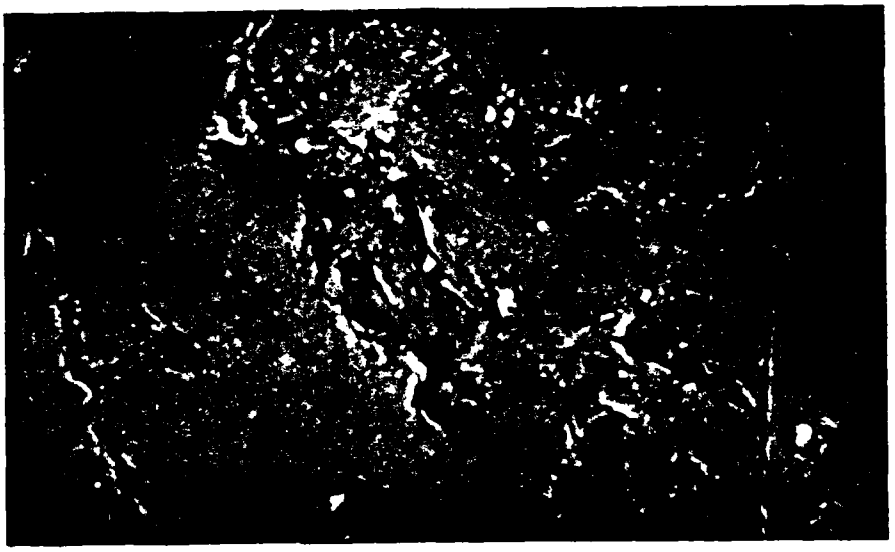

Figure 11. Photomicrograph of Deterioration to Surface of Cellulose Acetate Exposed at Key West for 2 Weeks, 1080X.

Figure 12. Photomicrograph of Deterioration to Surface of Cellulose Acetate Exposed at Fort Sherman Coastal Site for 2 Weeks, 520X.

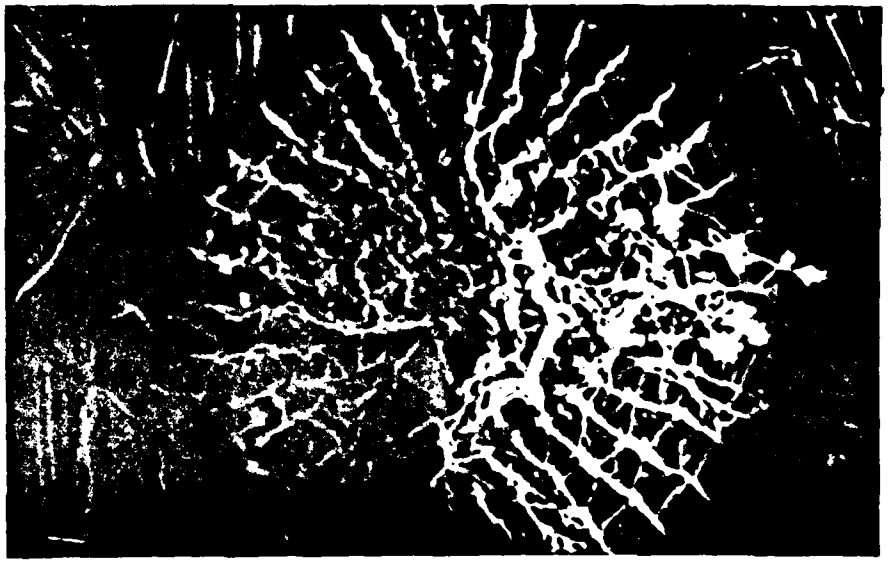

Figure 13. Photomicrograph of Fungi on Surface of Jungle Fatigue Strip Exposed at Fort Sherman Coastal Site for 2 Weeks, 160X.

Figure 14. Photomicrograph of Fungi on Surface of Jungle Fatigue Strip Exposed at Fort Sherman Coastal Site for 2 Weeks, 650X.

tentatively identified as belonging to the tricoderma species. Other unknown fungal species attacked cotton fibers (figure 15) exposed for 20 weeks at the Fort Sherman Coastal Site.

Fungal attack occurred either by a suction process as shown in figure 16, or by surface penetration as shown in figure 17. *Figure 16 shows the deterioration of latex after being exposed for* 4 months in Quinault. Figure 17 shows the deterioration of mylar after being exposed for 7 weeks at McKenzie Forest. Salt also can penetrate surfaces (figures 18 and 19) as shown on the mylar samples exposed at the Fort Sherman Open Exposure Site for 2 weeks (figure 18). The cellulose acetate sample (figure 19) exposed for 12 weeks at Key West showed severe surface salt penetration.

Another cause of surface deterioration is stress relaxation. A good example is shown in figure 20. The latex sample was exposed at the Quinault site for 7 months. After 7 months, a partial coalescence of surface particles had occurred. Stress relaxation from surface coalescence caused the surface fibers to pull apart. Surface deterioration at this site was so slow that the process was observed and analyzed easily. At sites with surface deterioration occurring rapidly, it was difficult to capture and analyze the deterioration process. High solar radiation levels found at the Fort Sherman Coastal Exposure Site caused surface deterioration to occur rapidly. Severe surface destruction occurred on latex samples exposed at this site for 2 weeks (figure 21).

Figure 15. Photomicrograph of an Unknown Fungi on Surface of Cotton Exposed at Fort Sherman Coastal Site for 20 Weeks, 2750X.

Figure 16. Photomicrograph of Fungi on Surface of Latex Exposed at Quinault for 4 Months, 1000X.

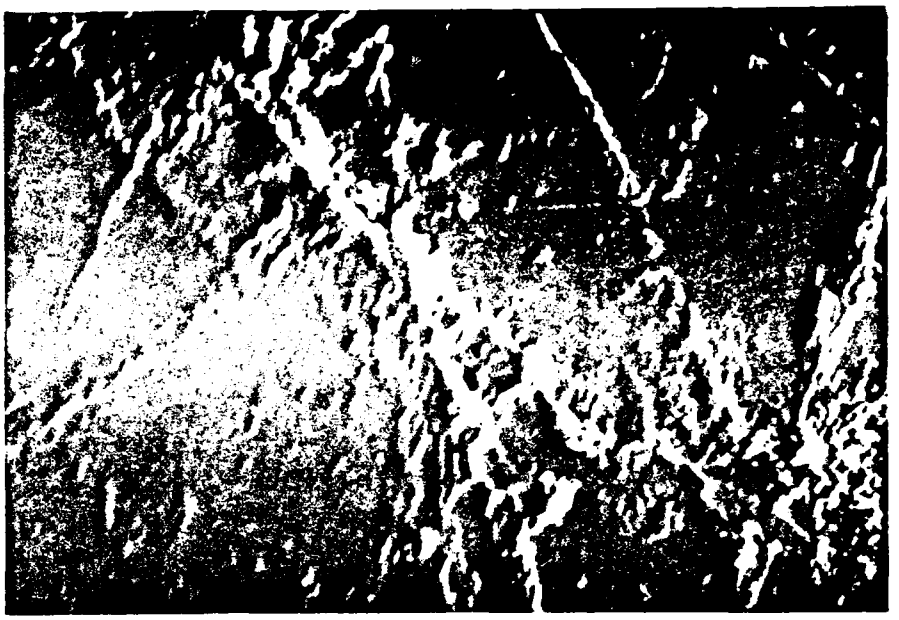

Figure 17. Photomicrograph of Fungi on Surface of Mylar Exposed at McKenzie Forest for 7 Weeks, 665X.

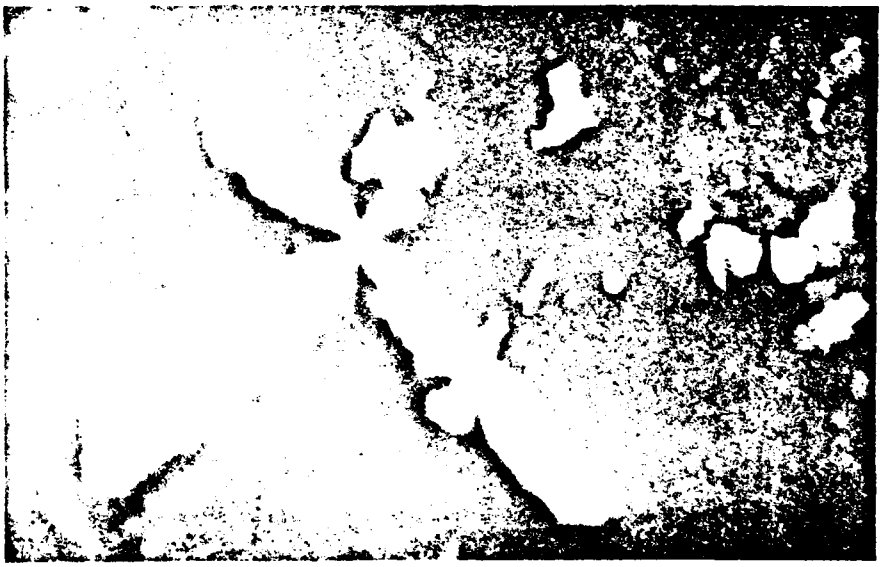

Figure 18. Photomicrograph of Salt Inside Surface of Mylar Exposed at Fort Sherman Open Site for 2 Weeks, 1800X.

Figure 19. Photomicrograph of Salt Inside the Surface of Cellulose Acetate Exposed at Key West for 12 Weeks, 1560X.

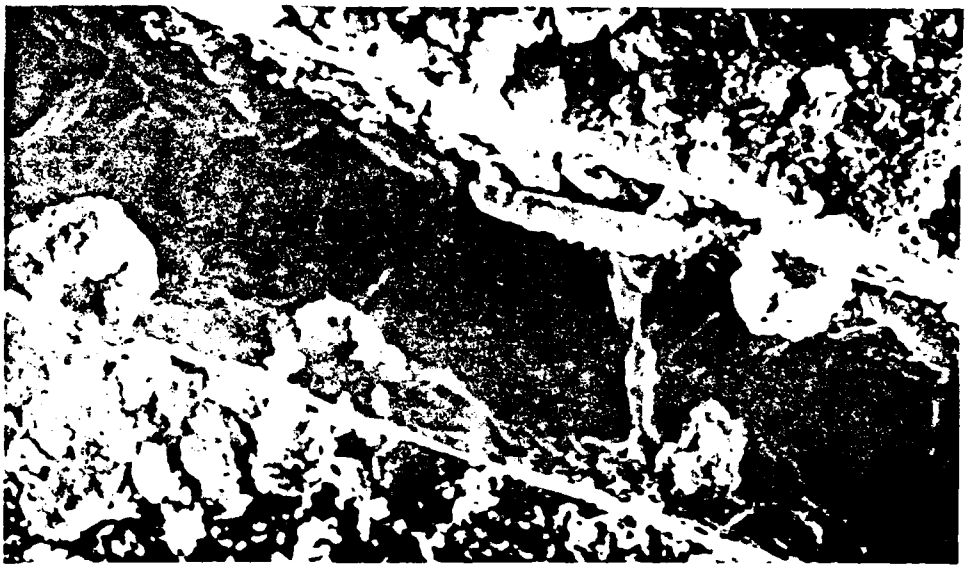

Figure 20. Photomicrograph of Surface Deterioration to Latex Exposed at Quinault for 7 Months, 1000X.

Figure 21. Photomicrograph of Surface Deterioration to Latex Exposed at Ft Sherman Coastal Site for 2 Weeks, 378X.

On occasion, unknown substances can be seen on exposed items. These substances, presumably of a biological nature, were found on POL tank fabrics exposed at the Fort Sherman Coastal Exposure Site for 2 weeks (figure 22). Phenomena of this nature are rarely encountered in samples exposed at CONUS Sites.

In conclusion, we are finding that some basic materials deteriorate at CONUS sites at rates similar to the deterioration rates found at sites in the tropics, although the deterioration mechanisms may be different. Future studies will index the severity of different mechanisms, develop a predictive model for material deterioration, and attempt to determine a valid procedure to predict materiel performance in the tropics using data obtained in CONUS.

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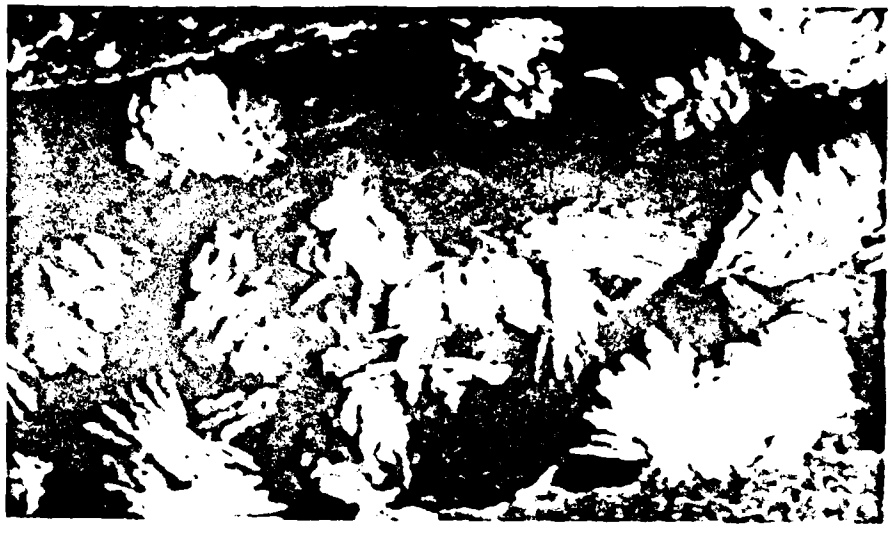

Figure 22. Photomicrograph of Unknown Substance on Surface of POL Tank Fabric Surface Exposed at Fort Sherman Coastal Site for 2 Weeks, 3850X.

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